AD-A184 818 EXTINCTION BY DIELECTRIC PARTICLES AT OPTICAL AND INFRARED WAVELENGTH(U) CLARKSON UNIV POTSDAM NY DEPT OF ELECTRICAL AND COMPUTER ENGI P W BARBER 31 AUG 87 1/1

UNCLASSIFIED ARO-21262 6-GS DAAG29-84-K-0054 F/G 20/6 NL

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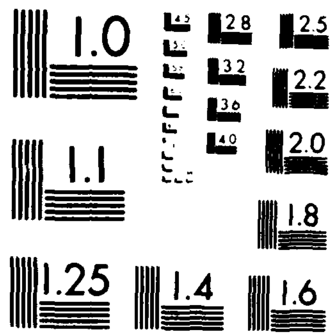

MICROCOPY RESOLUTION TEST CHART

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REPORT DOCUMENTATION PAGE

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1. REPORT NUMBER: ARO 21262.6-GS	2. GOVT ACCESSION NO.: N/A	3. RECIPIENT'S CATALOG NUMBER: N/A
4. TITLE (and Subtitle): Extinction by Dielectric Particles at Optical and Infrared Wavelengths		5. TYPE OF REPORT & PERIOD COVERED: Final, 1 June 1984 to 30 June 1987
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s): Peter W. Barber		8. CONTRACT OR GRANT NUMBER(s): DAAG29-84-K-0054
9. PERFORMING ORGANIZATION NAME AND ADDRESS: Department of Electrical and Computer Engineering, Clarkson University, Potsdam, NY 13676		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS: U. S. Army Research Office, Post Office Box 12211, Research Triangle Park, NC 27709		12. REPORT DATE: 31 August 1987
		13. NUMBER OF PAGES: 5
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)		15. SECURITY CLASS. (of this report): Unclassified
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

NA

18. SUPPLEMENTARY NOTES

The view, opinions, and/or findings contained in this report are those of the author(s) and should not be construed as an official Department of the Army position, policy, or decision, unless so designated by other documentation.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

T-matrix	multiple scattering
Mie theory	dielectric
light scattering	intensity
scattering matrix	resonance
	droplet

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Light scattering calculations for spheroidal particles have determined a relationship between the scattering matrix and the physical features of the particles. Multiple scattering calculations for parallel cylinders show that the coupling is greatest when one cylinder is in the shadow of the other. Slightly distorted spherical droplets exhibit new resonances which are caused by mode coupling.

ARO 21262.6-GS

EXTINCTION BY DIELECTRIC PARTICLES

AT OPTICAL AND INFRARED WAVELENGTHS

FINAL REPORT

Peter W. Barber

31 August 1987

U. S. Army Research Office

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Clarkson University

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A. Statement of the Problem Studied

The T-matrix and other theoretical scattering techniques were used to investigate the scattering features of dielectric particles. Calculations for nonspherical particles which are larger than the wavelength of the incident beam were of particular interest. Specific problems which were studied included determining the scattering matrix for randomly oriented spheroidal particles, calculating the intensity at the surface and internal to absorbing and nonabsorbing particles, and determining the resonance features of slightly distorted spherical particles.

B. Summary of Results

1. Information Content of the Scattering Matrix

Extensive calculations for spheroidal particles have shown that the frequency content of the phase function P11 is related to particle volume and that a parameter derived from the depolarization ratio 1-P22/P11 is related to particle shape. This was the first attempt to relate the physical characteristics of particles to their light scattering features in an organized way. These results should be useful in deducing the physical features of rod-like and disk-like particles from their measured scattering matrices.

2. Scattering Calculations for Finite-Length Cylinders

The T-matrix method was used to make the first scattering matrix calculations for a finite-length cylinder. Specifically, results were obtained for an absorbing 4:1 rod-like cylinder which was about two wavelengths in length. The physical characteristics conformed to a plastic cylinder for which measured results had been obtained at the Space Astronomy Laboratory at the University of Florida. The calculated and measured results were almost identical. These results show that the T-matrix method will be useful in solving scattering problems for particle shapes other than spheroids. It is important to note that calculations for either absorbing or nonabsorbing cylinders of differing axial ratios can easily be made with no changes to the computer program. The only limitation is that the T-matrix solution may not converge for cylinders of very low or very high axial ratios.

3. Multiple Scattering by Parallel Dielectric Fibers

A closed-form solution for the scattering by two parallel dielectric cylinders (originally due to Twersky) has been used to investigate the coupling between parallel glass fibers as a function of fiber size and separation. It was found that the coupling is strongly dependent on the orientation of the fibers relative to the incident wave, with end-on illumination giving the strongest coupling and broadside illumination giving the weakest coupling. Specific calculations of the backscatter efficiency for two fibers which are of resonant size show that the resonant wavelength shifts as the separation between the fibers decreases, and the resonances are completely damped when the fibers touch. The conclusion is that fibers of resonant size will have the greatest internal and external

near-field intensities when they are isolated or far removed from other fibers.

4. Intensity Within and Around Dielectric Objects

The spatial distribution of the near-field and internal electromagnetic intensities were calculated and experimentally observed for dielectric cylinders and spheres which are large relative to the incident wavelength. Two prominent features of the calculated results are the high-intensity peaks which exist in both the internal and near-fields of these objects, even for nonresonant conditions, and the well-defined shadow behind the objects.

5. Resonance Spectra of Slightly-Deformed Spheres

Spectral calculations of scattering efficiency vs size parameter show that numerous additional resonance peaks occur when a sphere is only slightly deformed to an equal-volume spheroid. This result may be important in predicting the enhanced intensities which would result when a liquid spherical droplet is slightly distorted, for example, by an incident high-intensity laser beam. Although the reason for the additional resonances can qualitatively be explained by considering the numerous new paths which are available for surface wave propagation when the sphere deforms, a quantitative explanation can be provided by the form of the T-matrix method which is used to calculate the results. The T-matrix is diagonal for spherical particles, which gives one-to-one coupling between incident field modes and scattered field modes. When a spherical particle is deformed, off-diagonal terms appear in the matrix, which results in mode coupling. This mode coupling is responsible for the additional resonance peaks which appear in the scattering.

C. List of Publications

P. E. Geller, T. G. Tsuei, and P. W. Barber,"Information Content of the Scattering Matrix for Spheroidal Particles," Applied Optics, 24, 2391, 1985.

M. P. Cline, P. W. Barber, and R. K. Chang,"Surface-Enhanced Electric Intensities on Transition and Noble-Metal Spheroids," Journal of the Optical Society of America B, 3, 15, 1986.

B. Schlicht, K. F. Wall, R. K. Chang, and P. W. Barber,"Light Scattering by Two Parallel Glass Fibers," Journal of the Optical Society of America A, 4, 800, 1987.

D. S. Benincasa, P. W. Barber, J-Z. Zhang, W-F. Hsieh, and R. K. Chang,"Spatial Distribution of the Internal and Near-Field Intensity of Large Cylindrical and Spherical Scatterers," Applied Optics, 26, 1348, 1987.

W. P. Acker, B. Schlicht, R. K. Chang, and P. W. Barber,"Quadrupole Mode in the Extinction and Elastic-Scattering Spectra of Gold Micro-structures, Optics Letters, 12, 465, 1987.

T. G. Tsuei and P. W. Barber, "Multiple Scattering by Two Parallel Dielectric Cylinders," Applied Optics, in preparation.

R. K. Chang and P. W. Barber, "Nonlinear Optical Interactions from Micrometer-Size Droplets," Progress in Quantum Electronics (invited), in preparation.

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Ph.D. degree expected, 1988.

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